Forward Markets: 
*The Absent Day-Ahead Market*

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Overview

• What is a day-ahead electricity market?
• Market design issues for day-ahead markets
• Benefits of operating a day-ahead market
• Why was the original day-ahead market in NZEM abandoned?
• Areas in NZEM where a day-ahead market may offer benefits
• What would day-ahead prices for NZEM look like?
• Actual day-ahead prices for PJM
• Day-ahead markets at a subset of nodes
• Conclusions
What is a day-ahead market?

- Operates a day in advance of actual operating day
- Allows both ‘financial’ and ‘physical’ participation
- Distinct from real-time markets but linked by ‘two-settlement system’
- Day-ahead price and quantity are ‘locked in’. Deviations managed by real-time market
Two-settlement system: example

Day-ahead mkt
Wed 3/9/03
1.30 - 2.00 am

Load
Buy 20MW at $10/MW

Generator
Sell 20MW at $10/MW

Real-time mkt
Thurs 4/9/03
1.30 - 2.00 am

Load
Sell 5MW at $9/MW

Generator
Buy 5MW at $9/MW

Forward contract for 20MW
Actual delivery is only 15MW

Total payment to generator = (20MW x $10) - (5MW x $9) = $155
Incentive-compatibility of two-settlement system

- Two-settlement system is incentive-compatible in that a generator has generally the same incentives in real-time market as if day-ahead market didn’t exist.
  
- Generator offers entire desired generation into real-time market. Deviations or mistakes are managed by two-settlement system.
  
- Symmetry means same incentives apply to electricity purchasers for their desired load.
Market design: centralised or decentralised trading (1)

(Trading Institution?)

• *Transaction costs*: centralising saves transaction costs

  Closer to real time – electricity product more homogeneous, higher demand, more transactions
  _trading platform to economise in transaction costs
  _centralised trading may be more cost effective

  Further from real time – electricity products differ, lower demand, fewer transactions
  _higher transaction costs
  _decentralised trading may be more cost effective
Market design: centralised or decentralised trading (2)

(Trading Institution?)

- Information Exchange
- Winner’s Curse:
  Common values _ winner’s curse, affects bidding/offering
  In electricity pay-as-bid auction, common value is price guessed.
  Winner’s curse _ submit higher offers

- Forward markets
  reveal information on common values so helps solve winner’s curse problem _ lower offers
  Centralised trading reveals information to more participants
Market design: uniform-price or pay-as-bid (1)
(Complementary?)

• Uniform-price – generators all paid market-clearing price
  Pay-as-bid – generators all paid what they offer

• Bidding behaviour:
  Competitive uniform-price – offer at marginal cost
  Pay-as-bid – offer at estimated price of electricity

• Potential Problems:
  Uniform-price – can be affected by exercise of market power
  Pay-as-bid – no dispatch order and large generators may have more resources to forecast price
Market design: uniform-price or pay-as-bid (2): Complementary Markets?

- Combination of uniform-price real-time and pay-as-bid day-ahead may improve price discovery.

- Why?
  In real-time, uniform-price provides least-cost dispatch order

  In day-ahead, dispatch order is not needed, and pay-as-bid may limit incentives for exercise of market power

- Note virtual bidding (arbitrage) => the average price in each market should be the same but be affected by the DA Mkt presence
Gaming the two markets
(Robert Michaels, 2003)

• At high loads, supply curve becomes very steep

• Demand-side can exercise market power:
  Understate load to achieve a lower day-ahead price, while
  making up the shortfall in the real-time market

• Requires:
  – no virtual bidding
  – uniform-price auction in both markets
Gaming the two markets

- Ways to counter this:
  1. Allow virtual bidding: generators submit a virtual load bid to counter understated load. This arbitrage across markets drives prices to converge.
  2. Allow a pay-as-bid day-ahead market: flat supply curve limits the incentive to understate load.
Benefits of day-ahead markets

• Increase reliability/certainty

• Promote demand-side participation

• Assist in unit-commitment

• Reduce impact of price uncertainty/volatility

• Reduce incentive for gaming
A day-ahead market in NZEM? Already tried and abandoned!

Possible reasons:

• Low price volatility

• ECNZ required to have 87% of capacity hedged in 1997

• Duopoly _ less competition

• Quick-start hydro-generation _ reliability and unit-commitment not such a problem
A day-ahead market in NZEM?
Already tried and abandoned!
Low price volatility

Standard Deviation of price
A day-ahead market in NZEM?
Times have changed!

Potential benefits in areas of:
• Demand-side participation

• Impact of price volatility

• Incentives for gaming

• Must-run generation

• Volatility on a river chain

• Administrative costs
Forecast of day-ahead prices in NZEM

• If DA market existed, how would prices compare with RT?

• For any node, for trading period i and day t estimate:

\[ P_{it} = f(\text{previous day's price } P_{it-1}) \]

• Use estimates to forecast day-ahead prices

\[ \hat{P}_{it} = \hat{f}(P_{it-1}) \]

• Guthrie and Videbeck (2002) _ forecasting prices from same trading period on the day before is reasonable_
NZEM Real-time and forecast day-ahead prices 2001

<table>
<thead>
<tr>
<th>Month</th>
<th>Real-time price</th>
<th>Forecast day-ahead price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan-01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apr-01</td>
<td></td>
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<td>Aug-01</td>
<td></td>
<td></td>
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<tr>
<td>Nov-01</td>
<td></td>
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</table>
NZEM Real-time and forecast day-ahead prices 2002
Is this a reasonable approach?

- Try where both a day-ahead and real-time market already exist

- PJM in Northeastern United States operates both day-ahead and real-time markets

- Following graph shows there is some merit in our approach
PJM Real-time, day-ahead and forecast day-ahead prices April 2003
Results of the forecasting experiment

- In NZEM, forecast day-ahead prices less volatile than real-time prices

<table>
<thead>
<tr>
<th>Year</th>
<th>Real-time Prices</th>
<th>Forecast Day-ahead Prices</th>
<th>Mean ($/MWh)</th>
<th>Standard Deviation ($/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>79.85</td>
<td>79.85</td>
<td>84.20</td>
<td>54.58</td>
</tr>
<tr>
<td>2002</td>
<td>40.16</td>
<td>40.16</td>
<td>29.32</td>
<td>7.04</td>
</tr>
</tbody>
</table>

- In PJM, actual day-ahead prices relative to real time prices
  - Have the same mean
  - are less volatile,
  - Have a less skewed and peaked distribution
Results of the forecasting experiment: PJM (April 2003)
Transactions and markets at different nodes

- Day-ahead markets need not operate at all nodes
- Fewer day-ahead nodes may give more participation at these nodes
- Example:

```
   C
  / \
 A   B
//       \
Day-ahead and Real-time market
  \\

  Real-time market only
```
Example: markets at different nodes

Day-ahead mkt
Wed 3/9/03
1.30 - 2.00 am

Load
Node A
(has both mkts)

Buys forward
20MW at
$10/MW

-$200

Real-time mkt
Thurs 4/9/03
1.30 - 2.00 am

Load
Node A
(has both mkts)

Sells back
20MW at
A's real-time price
($12/MW)

$240

Node B
(has RT mkt only)

Buys
20MW at
B's real-time price
($14/MW)

-$280

Total payment by load = -(20MW x $10) + (20MW x $12) -(20MW x $14)= -$240
Markets at different nodes and FTRs

• Day-ahead market at A provides a hedge for volatile real-time prices at B

• But only if real-time prices at A and B are ‘similar’

• Guthrie and Videbeck (2003): prices are similar over upper North Island, lower North Island and South Island suggests 2 or 3 day-ahead markets

• Financial Transmission Rights may complement day-ahead markets by limiting intra node volatility over longer periods
Conclusions

• Day-ahead markets are not a necessity but do provide additional benefits
• As it is close to real-time, a centralised trading day-ahead market may be more effective than a decentralised one
• The combination of pay-as-bid day-ahead market and uniform real-time market may improve price discovery
• Although tried and abandoned, times have changed and a day-ahead market in NZEM would offer benefits in some key areas
• Day ahead markets are forward markets